

# PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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## COMPLETE SPECIFICATION.

### Improvements in or relating to Flexible Tubing.

I, RALPH EDWIN DARLING, a Citizen of the United States of America, of 7805 Fairfax Road, Bethesda 14, Maryland, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement :—

The present invention relates to flexible tubing, particularly impervious flexible tubing for use in oxygen breathing and anæsthetizing apparatus, and to a method of its manufacture.

Flexible tubing is widely used in conjunction with oxygen-breathing apparatus for aircraft pilots and personnel. Such tubing is used in aircraft to connect personnel helmets or headgear to a central oxygen source aboard the aircraft, and, in cases of emergency, to portable sources of oxygen carried by the personnel or by their bale-out or ejection apparatus.

It has been discovered that oxygen tubing for aircraft use must meet specific minimum requirements as regards its flexibility, non-kinking characteristics and cross-sectional resistance to crush. It has been further discovered that, upon ejection or baling-out of aircraft personnel, the flexible character of oxygen tubing now used permits excessive and undesirable axial elongation or expansion of the tubing under the air stream resistance encountered. Such elongation, coupled with the movement of the personnel through the air stream, results in whipping and lashing of the tubing to the danger and peril of the ejected personnel.

It has also been a requirement of flight personnel oxygen equipment that the helmets or headgear worn be connected to electrical power communication equipment,

heaters, and the like. Certain efforts have been made to carry electrical circuits along the course of oxygen tubing to the headgear, either within the walls of the tubing or externally of the tubing. However, it has been found that wiring within the tubing walls is unsatisfactory by reason of breakage resulting from fatigue and stress produced by repeated flexing and twisting of the tubing. External wiring along the length of the tubing has also been found unsatisfactory for like reasons, and for the further reason that it presents an entangling obstacle to free movement of the tubing.

It is an aim of the present invention to overcome these disadvantages, and according to the invention a flexible tube comprises an impervious carcass of non-metallic material having helically-formed corrugations reinforced by reinforcing means which extend along the length of the carcass, and one or more restraining cords within the tube for limiting axial separation of the ends of the carcass.

Examples of flexible tubing in accordance with the invention are shown in the accompanying drawing, in which :—

Figure 1 is a side elevation of a finished tube ;

Figure 2 is a view similar to Figure 1 of a modified tube shown in partial section ;

Figure 3 is an enlarged fragmentary elevation in partial section of one end of a tube ;

Figure 4 is a side elevation in partial section illustrating one step in a method of manufacturing a flexible tube ;

Figure 5 is a side elevation in partial section illustrating another step in the manufacture of the tube ; and

Figure 6 is a view similar to Figure 5 illustrating a still further step in the method of manufacture.

The flexible tubing shown in Figure 2 comprises a carcass formed by an inner cylindrical tube 10 of rubber or like impervious, elastomeric material, and an outer sheath 14 encasing the inner tube. The inner tube 10 and the outer sheath 14 are corrugated between the convolutions of a helical spring 12 which is sandwiched between them, and the resulting unit is vulcanized or cured in such corrugated condition so that the spring 12 is embedded in the carcass. In addition, the tubing has end fittings 16 and 18 adapted to receive connectors of selective design, and is provided with a number of contiguous electrical leads or conductors 20 and restraining cords 22 extending coaxially of the bore of the inner tube 10 and projecting outwardly and radially through the side walls of the end fittings 16 and 18. The conductors 20 and the cords 22 are encased in a continuous sheath 24 of rubber or elastomeric material within the inner tube 10 and for a small distance outwardly from each of the two end fittings 16 and 18.

As is best seen in Figure 3, the restraining cords 22 are tied to the end coils of the spring 12 by looped end-sections thereof lying between the inner tube 10 and the outer sheath 14. The final curing of the composite tube serves to seal the joints in and about the points of projection of the sheath 24 through the fittings 16 and 18 so as to provide an impervious, gas-tight conduit between the extreme open ends of the end fittings of the tube and to provide completely sealed electrical conductors within the bore of the conduit.

The manufacture of the flexible tube is illustrated by Figures 4, 5 and 6. Thus, Figure 4 shows a section of a partially-cured, elastomeric tube 10 which is stretched longitudinally over a mandrel 26 to a predetermined elongation less than the elastic limit of the tube. After the stretched tube has been secured to the mandrel, I then apply a preformed metallic helical spring 12 of predetermined length telescopically over the tube and mandrel. The spring is expanded longitudinally to a preselected position of stretch, and the end coils 28 of the spring are secured to the tube. I then secure the intermediate convolutions of the spring 12 to the outer wall of the tube 10 by a helically-wound adhesive tape 30 or by cementing the spring to the tube wall.

The next step (shown in Figure 5) is to place a tubular sheath 14 of fabric or elastomeric material over the tube 10 and spring 12 in a tight fitting condition, whereupon the unit is transferred to a smaller mandrel as shown in Figure 6, and is corrugated by roping down the sheath 14 and tube 10 through the tight winding of nylon cord or wire 32 between the convolutions of the

spring. The unit is then partially cured or vulcanized while so roped.

I have found that, in order to facilitate handling and working of the tubing in its manufacture and to enhance certain desirable physical characteristics of the final tubing, it is desirable to bind together the last two and a half or so convolutions of the spring 12 at each end so as to form end coil rings 28 which are initially cemented or taped on the inner tube 10 during its manufacture.

Next, a wiring unit which consists of electrical conductors 20 and non-elastic restraining cords 22 sheathed in a reinforced tube 24 having an elastomeric, impervious cover is snaked coaxially through the bore of the corrugated unit described above, the extreme ends of the sheathed conductors being withdrawn radially outwardly through openings 34 in the walls of the tube beyond the ends of the helical spring. During this operation the outer sheath 14 of the composite tube unit is rolled back to expose the end coils 28 of the spring, whereupon continuous looped portions 36 of the restraining cords in the conductor tube are extracted radially of the conductor tube walls at points 38 (see Figure 3) immediately outside the walls of the corrugated tube where such looped portions are each tied at 40 to the adjacent end coil of the helical spring.

Lastly, the ends of the covering sheath 14 of the corrugated tube are drawn out taut and the ends of the tube 10 are placed in moulds into which elastomeric material is poured and then cured in order to form the end fittings 16 and 18 and to seal the joints at the points where the conductor tube projects through the walls of the end fittings. This moulding and curing operation further serves to bond the covering sheath 14 of the corrugated tube to the inner tube 10 about the end coils 28 of the spring.

In the form of the invention shown in Figure 1, the sheathed restraining cords 22 and electrical conductors 20 are normally positioned in a taut condition longitudinally of the tube. A tube constructed in this manner is completely restrained by the cords 22 against longitudinal elongation under any reasonable degree of axial tension. It will be noted that the end connectors on the tube shown also include a male plug 42 at one end and a female coupling 44 on the other. The number of electrical conductors 20 encased in the sheath 24 is optional according to the purposes for which the corrugated tube is to be used.

In Figure 2 a modified tube is shown wherein a predetermined length of slack is left in the sheathed electrical conductors 20 and the restraining cords 22 between their end portions so as to permit a predetermined elongation of the corrugated flexible tube

under axial tension. In order to avoid obstruction to gas or fluid flow in the bore of the corrugated tube, the slack portion of the sheath 24 may be formed with a pre-set spiral in order to cause it to assume a fixed, regular pattern within and adjacent the walls of the inner tube 10. The end connectors 46 and 48 of the tube are of different design to those shown in Figure 1 to suit different forms of installation.

In providing for restraint against the axial separation of the end coils of the reinforcing spring, certain modifications can be made to the constructions described above. For example, a single restraint cord could be run from one end to the other end of the tubing within the inner tube 10, and separate tie cord pieces, as opposed to loop sections, could be used to tie the restraint cord to the end coil rings of the spring.

It will therefore be seen that the tubular hose described above is flexible, non-kinking, resistant to radial compressive forces, and has means which limit or restrict longitudinal elongation. In addition, the tube acts as a carrier for electrical circuits needed to activate equipment normally necessary with oxygen-breathing headgear and the like. These circuits are completely sealed and insulated away from the gases or liquids passing through the tube and are located within the tube so as to avoid the use of external wiring which is always subject to entanglement and obstruction to free movement of the tube.

#### WHAT I CLAIM IS :—

1. A flexible tube comprising an impervious carcass of non-metallic material having helically-formed corrugations reinforced by reinforcing means which extend along the length of the carcass, and one or more restraining cords within the tube for limiting axial separation of the ends of the carcass.

2. A flexible tube according to Claim 1,

in which the reinforcing means comprise a helically-coiled spring under tension.

3. A flexible tube according to Claim 1 or Claim 2, in which the reinforcing means are embedded in the carcass.

4. A flexible tube according to Claim 3, in which the reinforcing means are embedded in the outer crests of the corrugated carcass.

5. A flexible tube according to any preceding claim, in which the restraining cord or cords are encased in an impervious sheath.

6. A flexible tube according to Claim 5, in which insulated electrical conductors are also encased in the impervious sheath, the ends of the conductors being withdrawn through openings in the wall of the tube at or adjacent its ends.

7. A flexible tube according to any preceding claim, in which looped portions near both ends of the restraining cord or cords are fastened or connected to the ends of the reinforcing means.

8. A flexible tube according to Claim 5 or Claim 6, in which the impervious sheath is made of an elastomeric material.

9. A flexible tube substantially as described with reference to Figure 1 and Figures 3—6, or Figure 2 and Figures 3—6.

10. A method of making a flexible tube according to Claim 1 which comprises applying a partially-expanded helical spring about an elastomeric impervious tube and securing the spring to the tube, covering the tube and spring to form a unit which is then corrugated and partially set, and extending a non-elastic restraining cord coaxially of the unit and tying the cord to the end turns of the spring.

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